(12) UK Patent Application (19) GB (11) 2 310 622 (13) A

(43) Date of A Publication 03.09.1997

(21) Application No 9604544.8

(22) Date of Filing 02.03.1996

(71) Applicant(s)
Black & Decker Inc.

(Incorporated in USA - Delaware)

Drummond Plaza Office Park,
1423 Kirkwood Highway, Newark, Delaware 19711,
United States of America

(72) Inventor(s)
Rudolf Jungwirth

(74) Agent and/or Address for Service
Darrin Shaya et al
Black & Decker, Patent Department, 177 Walsall Road,
BIRMINGHAM, B42 1BP, United Kingdom

(51) INT CL[6]
B23B 51/02, B21H 3/10

(52) UK CL (Edition O)
B3C C1B6G C1B6J C1B6N
B3M ME M3B M5 M9B M9L
U1S S1647

(56) Documents Cited
None

(58) Field of Search
UK CL (Edition O) B3C, B3M ME MG
INT CL[6] B21H, B23B
Online: WPI

(54) **Drill bit**

(57) A drill bit 1 has two opposed helical flutes 4, 6 separated radially by a web 7. The web tapers by at least 50% from a shank end 5 of the flutes to a working end 9 of the bit. The bit is roll formed from a blank by a pair of inclined rolls (Fig. 3) each of which have a spiral edge such that their separation diminishes to thereby form the taper. The cross-section of the bit varies from its shank end to its working tip (Fig. 9). The rolls have an asymmetric edge profile (Fig. 5) and may be formed by grinding (Fig. 4).

FIG. 1

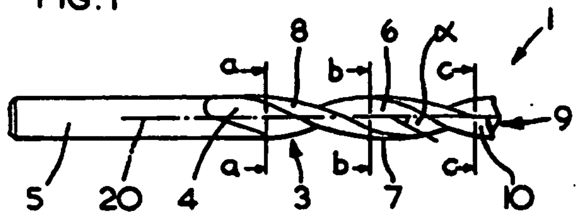
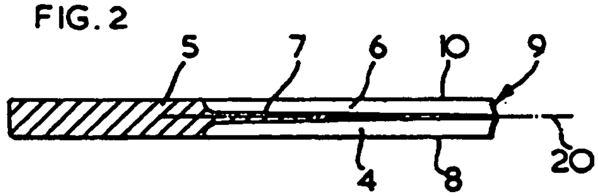


FIG. 2



GB 2 310 622 A

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG. 1

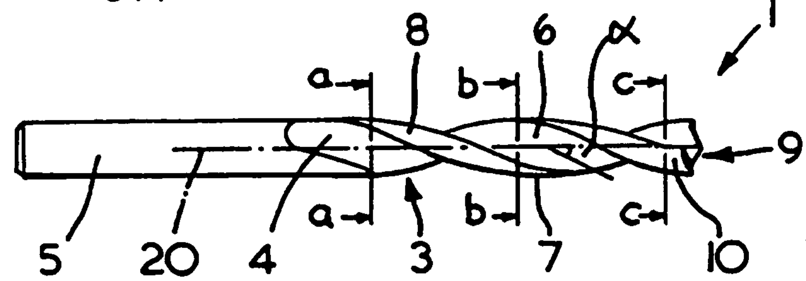
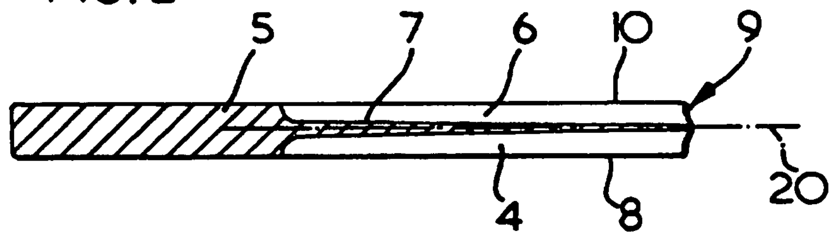


FIG. 2



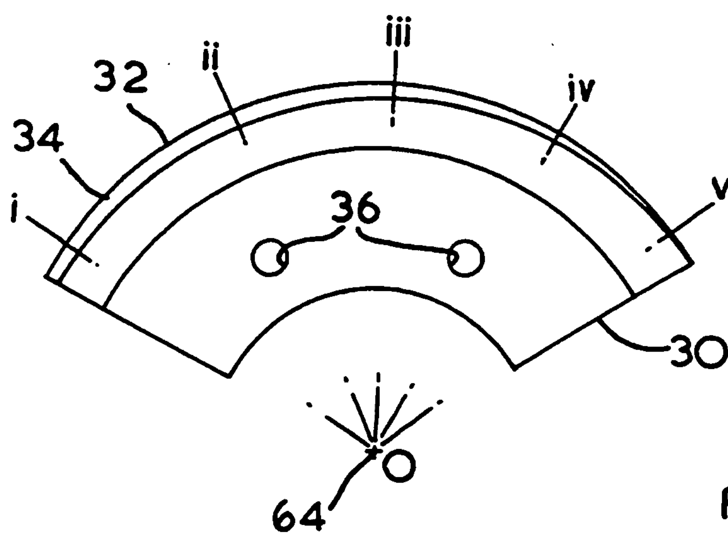


FIG. 3

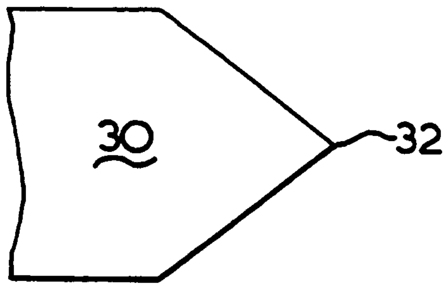


FIG. 4a

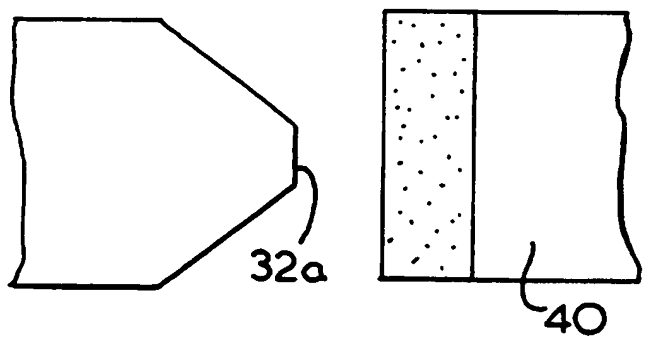


FIG. 4b

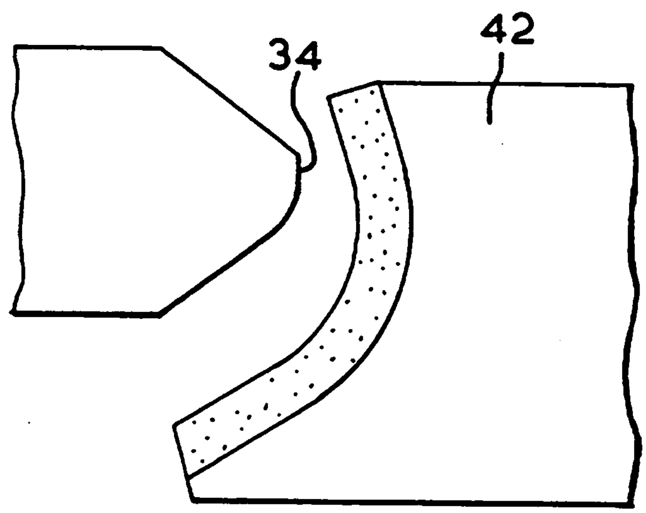


FIG. 4c

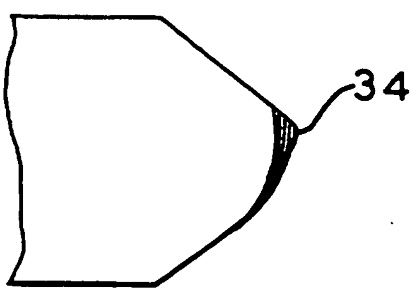


FIG. 4d

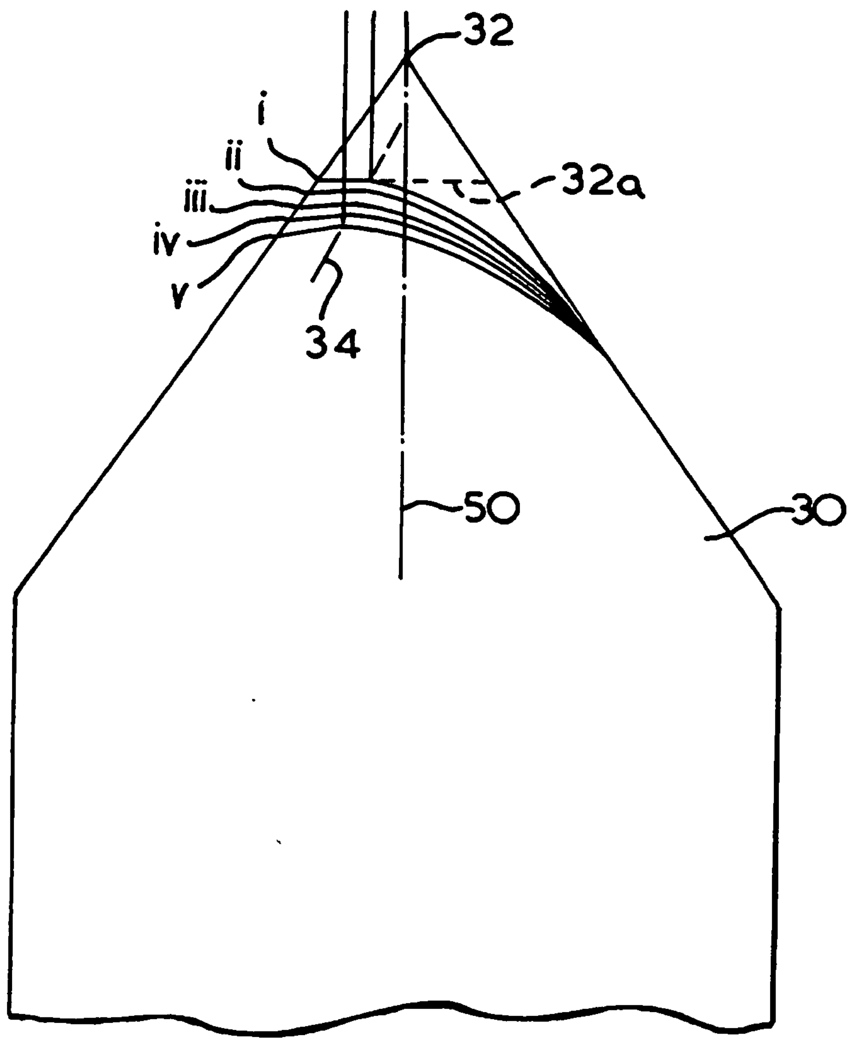


FIG. 5

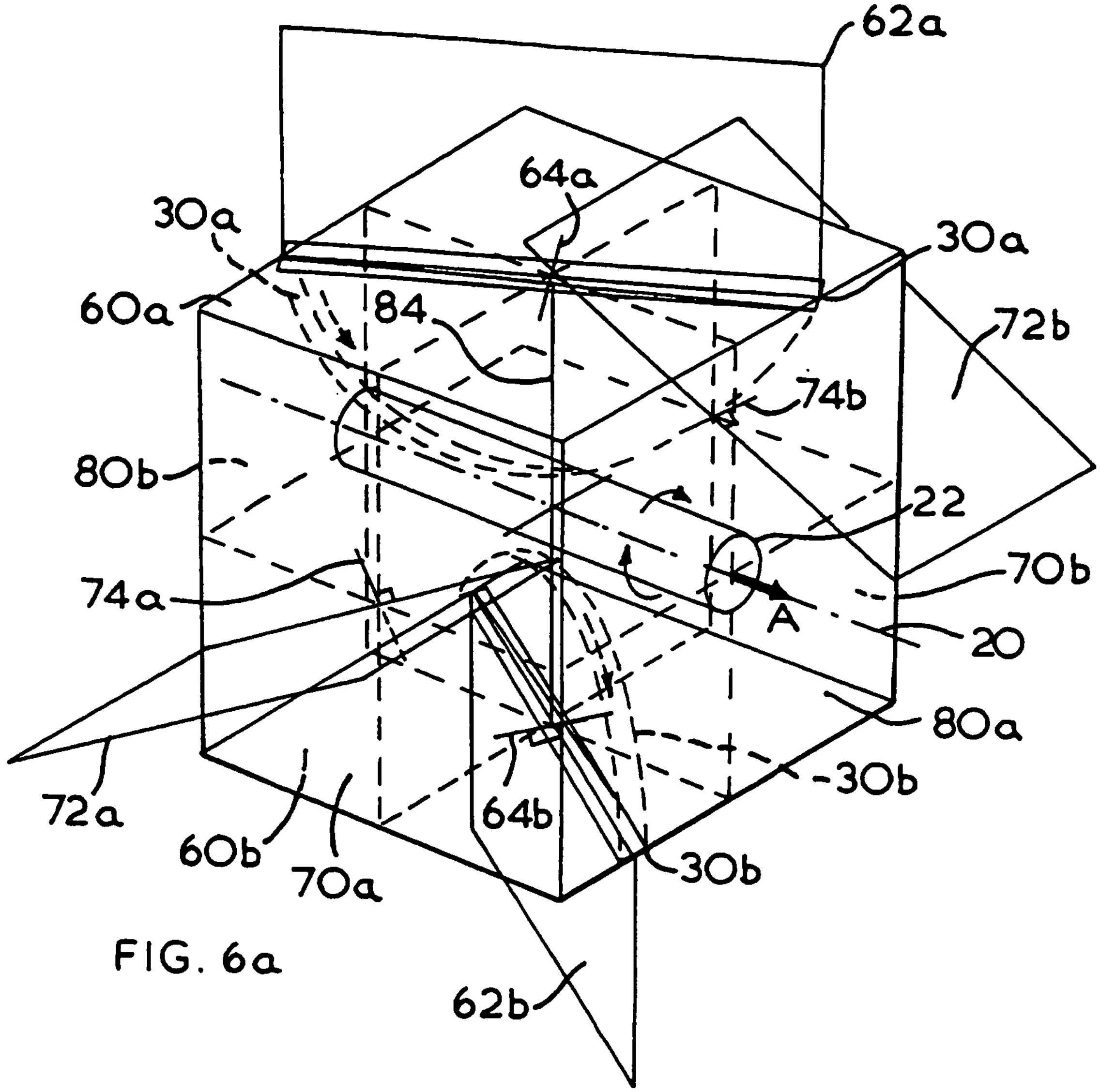

62a
64a
30a
30a
60a
84
72b
74b
80b
22
70b
74a
A
20
80a
30b
72a
64b
60b
70a
30b
62b

FIG. 6a

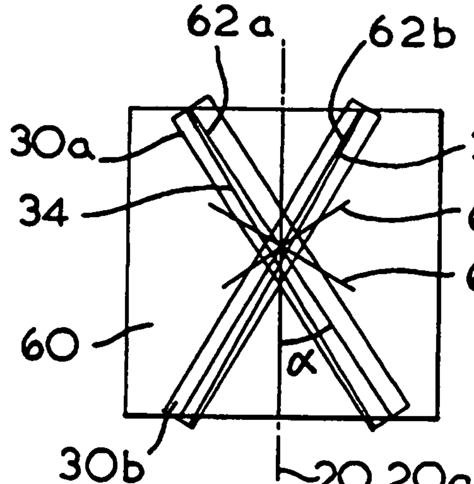

62a
62b
30a
34
34
64a
64b
60
α
30b
20,20a

FIG. 6b

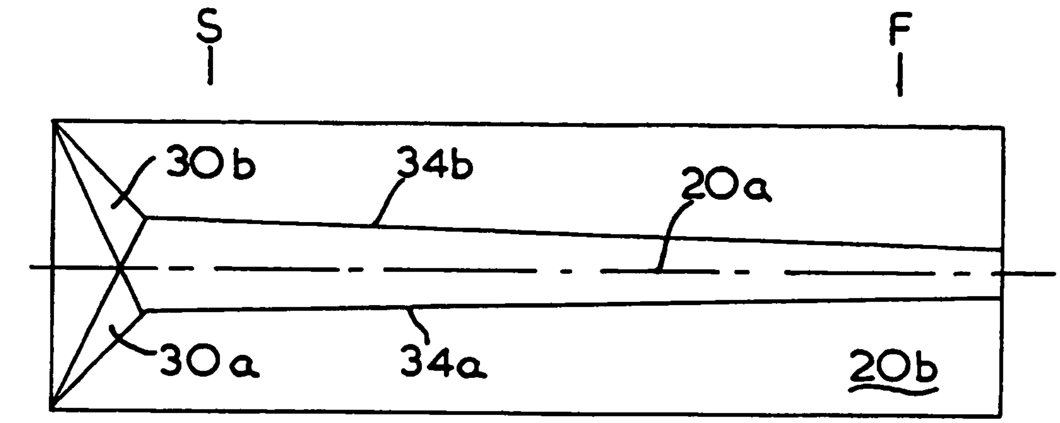


FIG. 7a

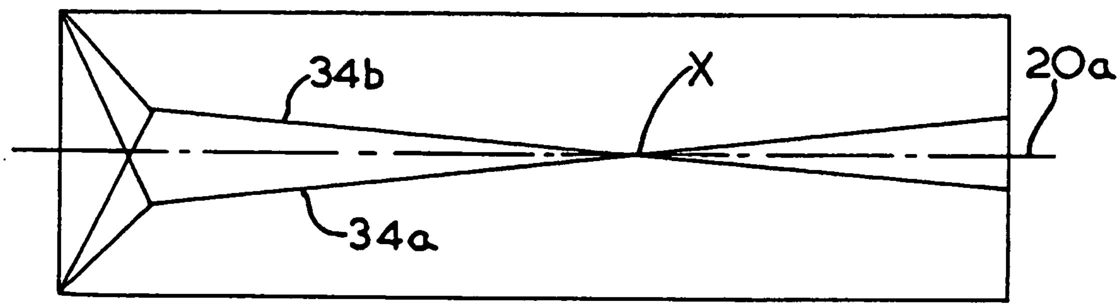


FIG. 7b

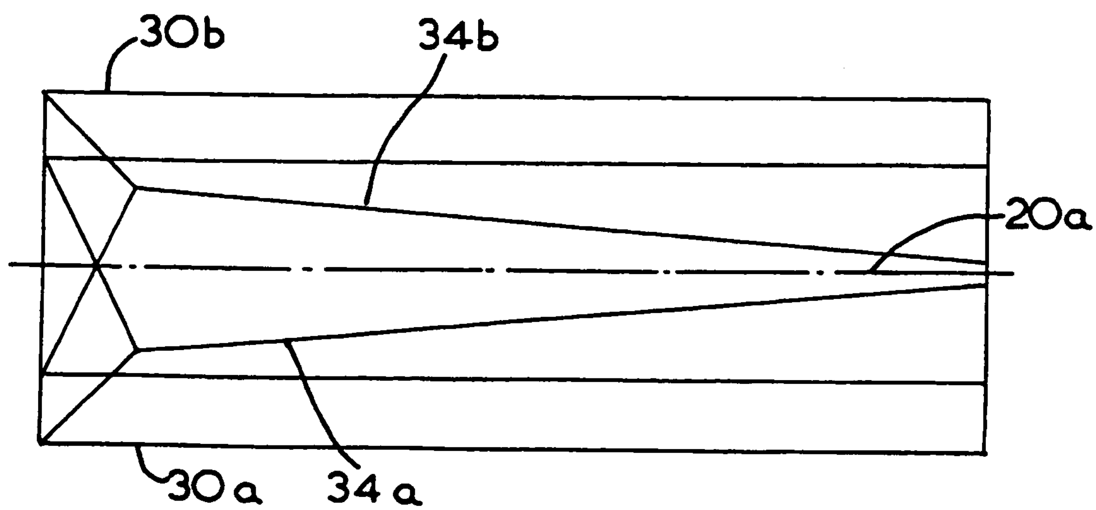


FIG. 7c

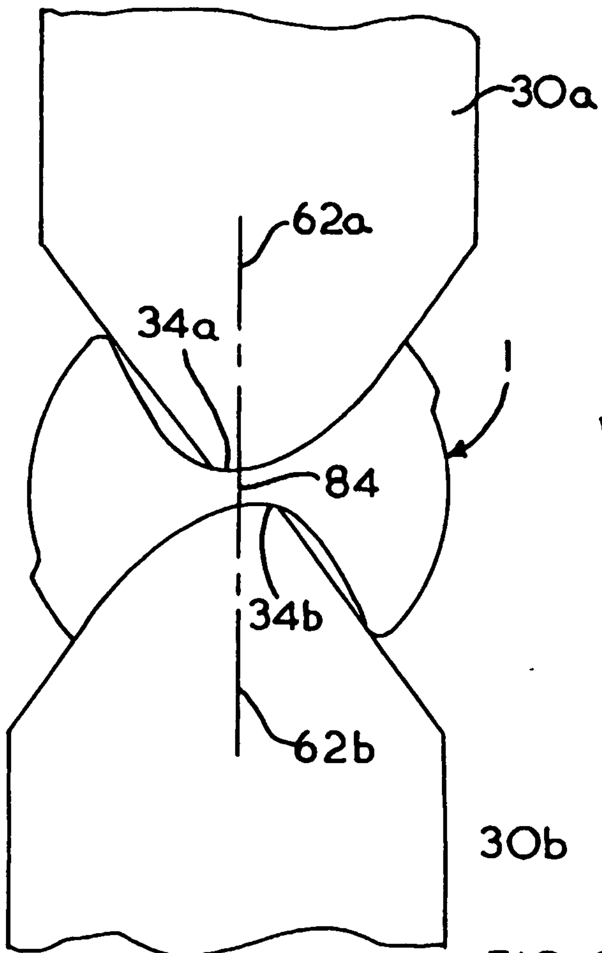


FIG. 8a

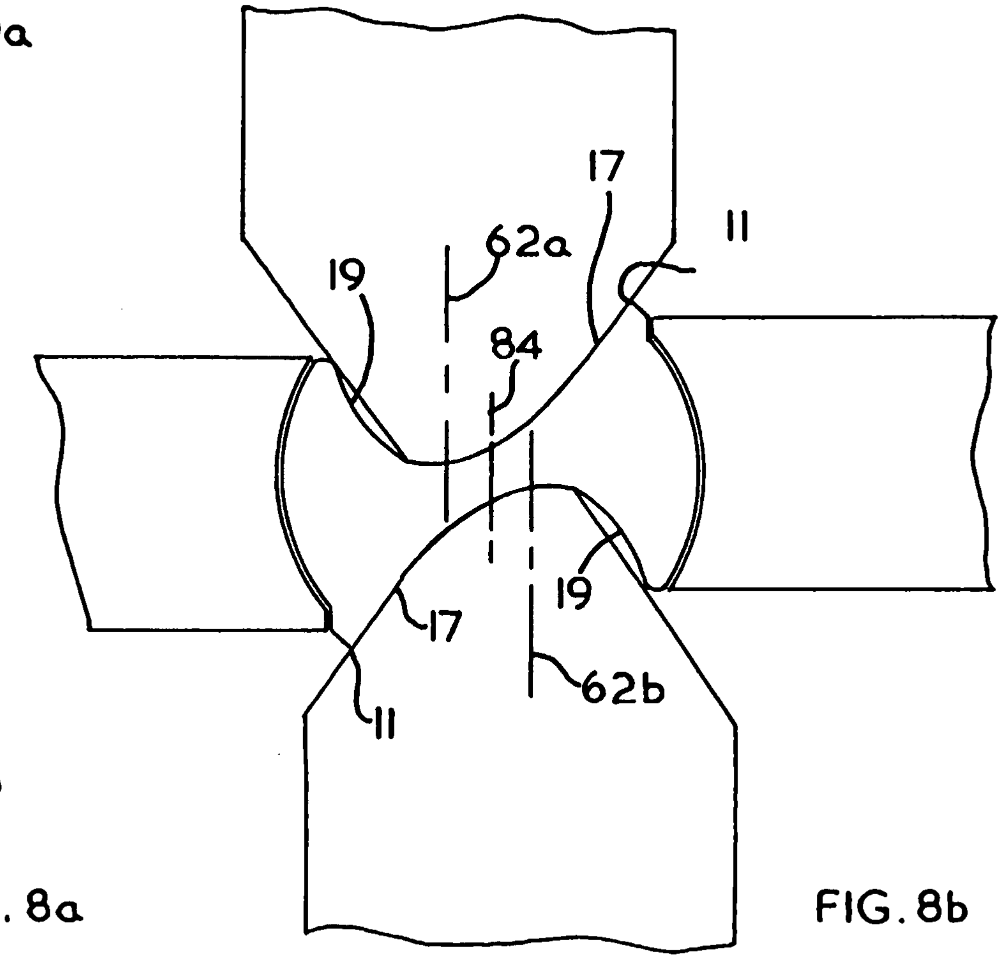


FIG. 8b

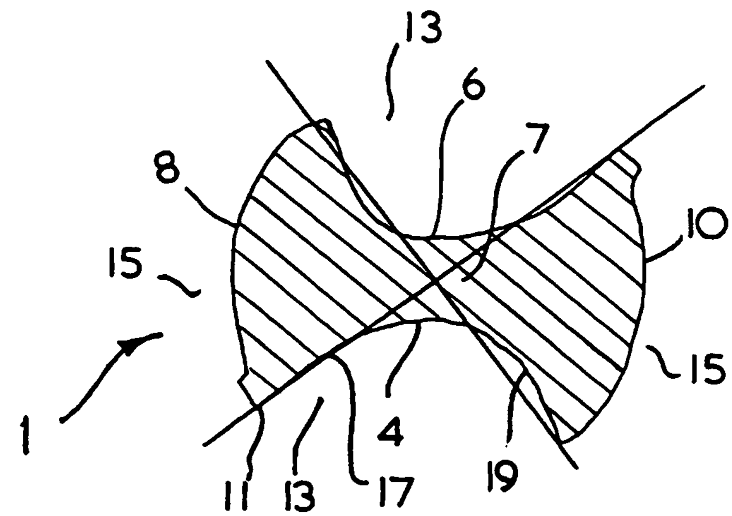


FIG.9a

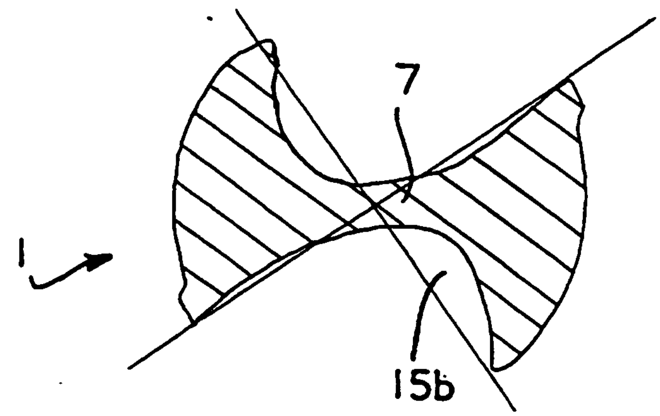


FIG.9b

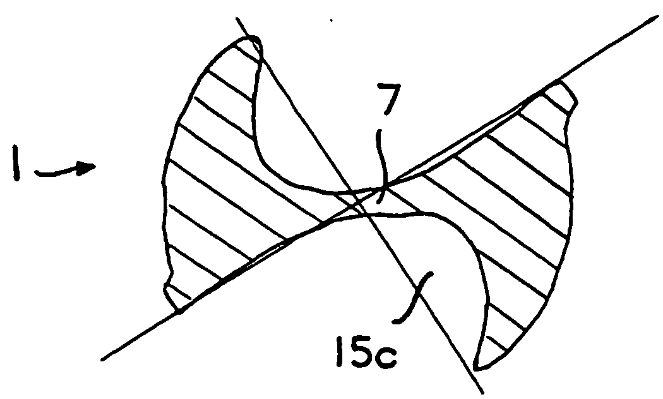


FIG.9c

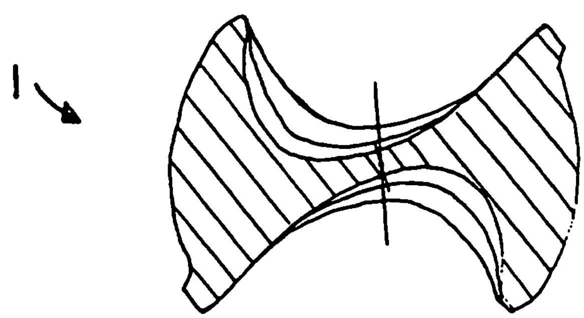


FIG.9d

2310622

Drill Bit - Roll Forging Process

This invention relates to a roll forging process for drill bits having two opposed helical flutes formed by the roll forging process, and wherein the web between said flutes tapers from a shank of the drill bit to its working tip, and to bits made by such process.

The invention finds particular application in a drill bit of the type described in our copending application filed 29 July 1995 under the number 9515593.3. Such drill bit is characterised, at least in preferred embodiments, by having a web whose thickness decreases from its shank end to as little as 30% of such thickness at its tip end. Web tapering to such an extent was hitherto unknown, at least in roll-formed drill bits, at the date of such application.

Flutes are formed in drill bits in a roll forging process by two opposed wheel sections whose axes are in substantially parallel "wheel axis" planes. The separation between the circumferences of the wheels determines the web thickness in the final drill bit. This is because a blank in the form of a circular section rod is drawn between the wheels as the wheels are rotated in opposite directions so as to assist drawing of the blank through the wheels. The profile of the wheels is in this way pressed into the surface of the blank.

Two supporting rollers have axes in parallel "roller axis" planes and whose circumferential surfaces support the sides of the drill bit as material of the blank is being squeezed out by the wheels to form the flutes. The wheel axis planes are perpendicular the roller axis planes, and both are parallel the axis of the blank. Finally, the degree of inclination of the wheel and roller axes in their respective wheel and roller axis planes and with respect to the blank axis when translated perpendicularly into each plane, is the same and determines the helix angle of the resulting drill.

When webs of different thickness are being formed, it is possible either to arrange for the wheels to come together to reduce web thickness, or to shape the wheels so that between the point at which they commence engagement with the blank to the point where they leave engagement, the wheel has changing radius, ie its circumference is spiral. In this latter case it is important that the point of initial engagement of the wheels with the blank is the same for each blank. In this case the wheel may not be complete around its axis but may only be a segment having the requisite length of arc to form the entire length of the drill bit.

It is apparent that in either case, as the blank proceeds through the forging wheels, a progressively increasing amount of the material displaced by the forging wheels is displaced axially rather than radially. Thus the length of the blank which is to form the fluted part of the drill bit is only about one third the length of

the finally fluted part of the bit, although this is substantially the case even if there is no web tapering.

The present invention is not concerned with roll forging processes in which the forging wheels are moved towards the drill bit during forging. It only applies where the wheels are of spiral edge configuration. That is because, in that process, the method of forming the wheel segments, as further described below, results in the edge of the forging wheel lying in a plane which is not radial with respect to the axis of the forging wheel. This is not a problem when the taper being formed is only marginal, which hitherto has been the norm, but a problem has arisen where the taper is substantial, as described in the afore-mentioned patent application. In this event, the centres of spread (as defined hereinbelow) of the two forging wheels cross one another at some point along the drill bit, and this fact has been identified as the cause of a problem experienced. This problem is that the concentricity of the final drill bit cannot be guaranteed.

The "centre of spread" of a roll forging wheel is hereby defined as that point on the periphery of the wheel, given the position of the wheel in relation to the opposing wheel, the blank between them and any support rollers employed, where the flow of material being squeezed out between the wheels is to either side of such centre. Such centre of spread is usually indicated by a discrete edge of the wheel having maximum radius.

The flow of material sideways as the blank passes between the rollers is affected by the profile of the edge of the forging wheels. While there is symmetry in the profile, or at least the lack of symmetry is consistent around the circumference of the forging wheels, the flow to each side of the centre of spread can be predicted and controlled by the side supporting rollers. However, it has been discovered that irregular shaping of the drill bit is caused when the centres of spread cross one another at some point along the length of the drill bit. It appears that in that region there is some, probably very small, variation in the direction material flows from one bit to the next, but sufficient to make a noticeable difference in consistency in the concentricity of the final bit.

It is an object of the present invention to improve the roll forging process to overcome this problem, or at least to mitigate its effects.

In accordance with this invention there is provided a method of roll forging a drill bit having two opposed helical flutes, wherein the drill bit is roll formed from a blank in apparatus which comprises:

a) two forging wheels disposed opposite one another and adapted to form the flutes and whose axes lie in first and second substantially parallel wheel axis planes; wherein

b) the blank is disposed between the wheels on a blank axis parallel said wheel axis planes;

c) a blank plane contains said blank axis and is

perpendicular said wheel axis planes;

d) the wheel axes are inclined in their respective wheel axis planes with respect to the blank plane and on opposite sides thereto and whereby the helix angle of the drill bit is determined;

e) the wheels have a spiral circumference which is sufficient to ensure that a web formed between said flutes tapers by at least 50% from a shank end of said flutes to a working end of the drill bit;

f) the wheels have an asymmetric edge profile having a centre of spread as defined herein, wherein each centre of spread moves axially with respect to the respective wheel axis and towards said blank plane as each wheel rotates from a start position to an end position; said method being characterised in that, in said apparatus

g) said wheel axes are positioned in said wheel axis planes such that said centres of spread of the wheels remain one on either side of said blank plane during rotation of the wheels from said start position to said end position.

Preferably,

h) two supporting rollers are disposed opposite one another and adapted to support the sides of the drill bit and constrain material squeezed out of a blank by the forging wheels, the axes of said rollers lying in first and second substantially parallel roller axis planes; and wherein:

i) said roller and wheel axis planes are substantially

mutually perpendicular and are each parallel said blank axis and the direction of draw of said blank between the wheels and rollers.

The invention also provides drill bit roll forging apparatus for roll forging a drill bit having two opposed helical flutes, said apparatus comprising:

a) two forging wheels disposed opposite one another and adapted to form the flutes and whose axes lie in first and second substantially parallel wheel axis planes; wherein

b) a blank is adapted to be disposed between the wheels on a blank axis parallel said wheel axis planes;

c) a blank plane contains said blank axis and is perpendicular said wheel axis planes;

d) the wheel axes are inclined in their respective wheel axis planes with respect to the blank plane and on opposite sides thereto and whereby the helix angle of the drill bit is determined;

e) the wheels have a spiral circumference sufficient to form a web between said flutes which tapers by at least 50% from a shank end of said flutes to a working end of the drill bit;

f) the wheels have an asymmetric edge profile having a centre of spread as defined herein, wherein each centre of spread moves transversely with respect to the respective wheel axis as each wheel rotates from a start position to an end position; characterised in that,

g) said wheel axes are positioned in said wheel axis planes such that said centres of spread of the wheels remain one on either

side of said blank plane during rotation of the wheels from said start position to said end position.

Preferably,

h) two supporting rollers are disposed opposite one another and are adapted to support the sides of the drill bit and constrain material squeezed out of a blank by the forging wheels, the axes of said rollers lying in first and second substantially parallel roller axis planes; and wherein:

i) said roller and wheel axis planes are substantially mutually perpendicular and are each parallel said blank axis and the direction of draw of said blank between the wheels and rollers.

Thus by displacing the wheels outwardly along their respective axes and thus ensuring that the centres of spread of the respective wheels do not cross over with respect to each other, sideways flow of the blank material can be more precisely controlled so that uniformly concentric drill bits can be produced, even when the degree of taper of the flute web is substantial.

Indeed, by employing the method and apparatus of the present invention a novel drill bit is produced. Thus the present invention also provides a drill bit having two opposed helical flutes and a web between said flutes which tapers by at least 50% from a shank end of said flutes to a working end of the drill bit, wherein the drill bit is roll formed from a blank, characterised in that the cross-section of the drill bit changes from its shank end to

its working tip, such cross-section comprising quadrants defined by a diameter of the section from a front cutting lip of one flute to the corresponding cutting lip of the other, each flute primarily occupying opposing flute quadrants, wherein such cross-section changes from shank end to working tip not only by virtue of a decreasing web thickness, but also by the flute increasingly being incursive into the quadrant ahead of the flute quadrant in the direction of cutting rotation of the drill bit.

Preferably said incursion is substantially parabolic in shape.

The invention is further described hereinafter, by way of example, with reference to the accompanying drawings, in which:-

Figure 1 is a side view of a drill bit according to the present invention and capable of being roll formed by the method and apparatus of the present invention;

Figure 2 is a longitudinal section along a helical surface through the web of the drill bit in Figure 1;

Figure 3 is a side view of a roll forging wheel, before and after grinding;

Figures 4a to d show the grinding process to obtain a forging wheel for use in the present invention;

Figure 5 is a section of the forging wheel, after grinding, taken on radial planes i-o to v-o in Figure 3;

Figure 6a is a perspective view of a cubic space around a blank

to be roll formed and showing planes and axes of the roll forging wheels and support rollers, Figure 6b being a top view of the cube;

Figures 7a to c are views of the lines described in a forging plane of the blank during roll forging;

Figures 8a and b being sections through the roll forging wheels and drill bit, conventionally in Figure 8a and according to the present invention in Figure 8b; and,

Figures 9a to c being sections on the lines **a-a**, **b-b** and **c-c** respectively in Figure 1, Figure 9d being all three super-imposed on one another.

Figure 1 shows a drill bit 1 having a fluted section 3, a shank 5 and a pointed end 9. There are two opposing flutes 4,6 separated radially by a web 7. Two lands 8,10 separate the flutes circumferentially. The flutes are formed in a roll forging process by heating a blank steel or other appropriate material rod to a temperature at which it becomes malleable, and drawing it between two opposed roll forging wheels. If axially aligned flutes were requires, the wheels would be aligned with the axis of the blank and the blank would simply be drawn from its shank end 5 through the wheels which would be rotated during drawing. This would be unusual, however, and normally the flutes are formed as a helix having a helix angle α with respect to a blank axis 20. In this event, the axis of each wheel is inclined as described further below and the blank is rotated about its axis during drawing.

In the drill bit described in our above-mentioned patent application, the geometry of the point 9 benefits from having a narrow web 7 at the point. However, such a narrow web cannot adequately support the drill cross section along its entire length and so it is desirable to arrange for the web to taper, and to such an extent that its thickness at its point is only about 30% of its thickness at its shank end. It is conventional to have a slight taper, but not of this extent, and in forming drill bits with this degree of taper a problem has developed.

There are essentially two ways of roll forging the taper. One way is to control the position of the forging wheels and to bring them towards one another as the drill is being drawn, so that the web formed between them gets progressively narrower. Such a method is expensive, however, in terms of control equipment, given the not inconsiderable forces employed. The second method is to arrange for the wheels to be of spiral configuration so that their separation diminishes as they rotate from a start position to a finish position. This is much simpler to organise and execute (only needing to ensure that forging commences at the same point on the forging wheels so that the thickness of the web is consistent) and is therefore a less expensive process to employ.

The present invention is concerned with the second process and Figure 3 shows a forging wheel 30 which is formed as an annular segment having a circular periphery 32 centred at o. The edge is ground as described below to give a spiral edge 34. Holes

36 enable the wheel to be bolted to a carrier (not shown), enabling rotation of the wheel 30 about centre **o** and referred to below as wheel axis 64.

In Figure 4, wheel segment 30 first has a knife edge profile 32 as shown in Figure 4a. This is then ground into a circular profile with a flat edge 32a by a cylindrical surfaced grinding wheel 40. Then a curved surface grinding wheel 42 is applied which forms a curved and spiral surface 34.

Figure 5 shows the profiles of the wheel, firstly before any grinding (at 32), then the second stage (at 32a), and then the various profiles on the lines **i-o** in Figure 3 to **v-o** in that drawing. From this it can be seen that the edge 34 is no longer parallel the radial plane 50 of the wheel segment 30.

The general process of roll forging of drill bits is well known in the art and is not described in detail herein.

However, Figure 6a is a schematic diagram of a cubic space 100 surrounding a blank 22 to be roll-forged. The space 100 has top and bottom faces (wheel axis planes) 60a,b; side faces (roller axis planes) 70a,b and front and rear faces 80a,b. The blank 22 is shown in a central blank axis 20 which is perpendicular the end faces 80. The blank lies in blank plane 20a, which is perpendicular the wheel axis planes 60 and parallel the roller planes 70. It also lies in a forging plane 20b, which is parallel the

wheel axis planes 60 and perpendicular the roller planes 70. Wheel planes 62a,b are perpendicular wheel axis planes 60a,b respectively and contain the planes of forging wheels (not shown). Similarly, roller planes 72a,b are perpendicular roller axis planes 70a,b respectively and contain the planes of blank support rollers (not shown). Wheel axes 64a,b are in planes 60a,b respectively and are perpendicular wheel planes 62a,b respectively. Similarly, roller axes 74a,b are in planes 70a,b respectively and are perpendicular roller planes 62a,b respectively.

Planes 62 and 72 are each inclined with respect to blank planes 24,26 by angle α which determines the helix angle of the final drill bit. Blank 22 is drawn through the wheels (30a,b shown dotted) and rollers (not shown) in direction of arrow A, while being rotated about its axis 20 in the direction shown. The wheels and rollers are simultaneously rotated about their respective axes in the directions shown.

[It will of course be immediately apparent to the skilled reader that the arrangement shown in Figure 6 is for producing left hand thread drill bits, for which there is not a great deal of demand, commercially. However, a person skilled in the art will not be taxed unduly in his/her investigations into how the Figure 6 arrangement may be modified to produce the more usual right hand thread drill bits!]

Figures 7a to c show the superimposed profiles of two facing wheels 30a,b in the forging plane 20b of the blank (not shown) as the wheels are rotated from a start position S to a finish position F. The distance between S and F is the length of the flutes formed in the fluted section of the drill bit. In Figure 7a, the degree of taper required is small and so the edges 34a, 34b, representing in this case the centres of spread of each wheel, do not cross over one another. In Figure 7b, the taper is more excessive and it has been discovered that here the centres of spread 34 cross one another at X, and also cross the blank plane 20a. In this condition it has been found that in the region of the cross over the direction of flow of the material of the blank cannot be accurately, reliably or repeatably predicted and consequently sometimes it flows more to one side than the other, and at other times, vice versa. This results in the drill bit in this region having more material on one side than it should and so deforming slightly irregularly on cooling, so that the drill bit is no longer concentric. Why this should happen is not clearly understood, and may be because the direction of reaction forces against the forging wheels caused by the blank probably changes at the cross-over point X.

Consequently the invention suggests displacing the wheels slightly so that the cross over does not occur and in this way more precise roll forging has indeed found to be achieved. This is shown in Figure 7c. Here the wheels 30 are each displaced along

their axes so that the footprint of the two wheels in the forging plane 20b is as shown.

This is also shown in Figure 6a and b where a contact line 84 connects wheel axis planes 60 and is perpendicular thereto and also passes through the blank axis and is perpendicular thereto. Finally, it lies in the blank plane 20a. The contact line is also contained in the wheel planes 62 and so in Figure 6b, the planes 62 represent that plane of the wheels which coincides with the blank plane 20a as the wheels rotate about their respective axes 64 and through the contact line 84.

Thus in Figure 6b especially, the centre of spread 34 is shown for each wheel and this can be seen to remain always on one side of the wheel plane 62 and so that it never crosses the blank plane 20a. This is achieved most simply by displacing the wheels along their respective axes away from the planes 62, ie wheel 30a rightwardly in Figure 6b along its axis 64a and wheel 30b leftwardly in Figure 6b along its axis 64b. However, there are other ways of achieving the same result, for example by displacing the wheel axes at some angle to their own axes, but this may lead to other problems of control, not necessarily beyond the ordinary skills of the relevant art.

Figures 8a and b show a conventional arrangement in which roll forging wheel 30a,b are aligned with respect to one another, ie the contact line 84 is coincident with their planes 62a,b.

In Figure 8b, the planes 62a,b have each been shifted away from the contact line 84 (plane 20b) so that the centres of spread 34a,b of the two wheels do not overlap at any position of the wheels between their start and end positions of the roll forging process. Face 17 of the flutes which terminate at cutting lips 11 are precisely determined by the shape of the grinding wheels 30. The other, trailing face 19 is formed by spill-over from edge 34.

The process and apparatus of the present invention results in a novel drill bit construction, at least of a roll forged drill bit. This is illustrated in Figure 9 wherein the cross-sectional profile of the drill bit changes from the shank end of its fluted section to its working end.

In Figure 9a, the profile is taken near the shank end and the profile can be divided into four quadrants defined by the diameter of the drill bit passing through cutting lips 11 of each land 8,10. Near the drill shank, the flute substantially only occupies a flute quadrant. As the profile is taken towards the working tip, as shown progressively in Figures 9b and 9c, the flutes become more incursive into the quadrant 15 in front of each flute quadrant 13 in the direction of rotation of the drill during normal drilling operation, as shown at 15b and 15c. This is superimposed on a reducing web thickness 7. Thus at the tip (near the Figure 9c profile), the web 7 is at its thinnest which results in a particularly sharp point of the drill bit resulting in less tendency of the drill bit to wander, or skate, across a workpiece when first offered up to it.

16

The shape of the incursion is substantially parabolic.

CLAIMS

1. A method of roll forging a drill bit having two opposed helical flutes, wherein the drill bit is roll formed from a blank in apparatus which comprises:

a) two forging wheels disposed opposite one another and adapted to form the flutes and whose axes lie in first and second substantially parallel wheel axis planes; wherein

b) the blank is disposed between the wheels on a blank axis parallel said wheel axis planes;

c) a blank plane contains said blank axis and is perpendicular said wheel axis planes;

d) the wheel axes are inclined in their respective wheel axis planes with respect to the blank plane and on opposite sides thereto and whereby the helix angle of the drill bit is determined;

e) the wheels have a spiral circumference which is sufficient to ensure that a web formed between said flutes tapers by at least 50% from a shank end of said flutes to a working end of the drill bit;

f) the wheels have an asymmetric edge profile having a centre of spread as defined herein, wherein each centre of spread moves axially with respect to the respective wheel axis and towards said blank plane as each wheel rotates from a start position to an end position; said method being characterised in that, in said apparatus

g) said wheel axes are positioned in said wheel axis planes

such that said centres of spread of the wheels remain one on either side of said blank plane during rotation of the wheels from said start position to said end position.

2. A method as claimed in claim 1, wherein:

h) two supporting rollers are disposed opposite one another and adapted to support the sides of the drill bit and constrain material squeezed out of a blank by the forging wheels, the axes of said rollers lying in first and second substantially parallel roller axis planes; and wherein:

i) said roller and wheel axis planes are substantially mutually perpendicular and are each parallel said blank axis and the direction of draw of said blank between the wheels and rollers.

3. Drill bit roll forging apparatus for roll forging a drill bit having two opposed helical flutes, said apparatus comprising:

a) two forging wheels disposed opposite one another and adapted to form the flutes and whose axes lie in first and second substantially parallel wheel axis planes; wherein

b) a blank is adapted to be disposed between the wheels on a blank axis parallel said wheel axis planes;

c) a blank plane contains said blank axis and is perpendicular said wheel axis planes;

d) the wheel axes are inclined in their respective wheel axis planes with respect to the blank plane and on opposite sides thereto and whereby the helix angle of the drill bit is determined;

e) the wheels have a spiral circumference sufficient to form

a web between said flutes which tapers by at least 50% from a shank end of said flutes to a working end of the drill bit;

f) the wheels have an asymmetric edge profile having a centre of spread as defined herein, wherein each centre of spread moves transversely with respect to the respective wheel axis as each wheel rotates from a start position to an end position; characterised in that,

g) said wheel axes are positioned in said wheel axis planes such that said centres of spread of the wheels remain one on either side of said blank plane during rotation of the wheels from said start position to said end position.

4. Apparatus as claimed in claim 3, wherein:

h) two supporting rollers are disposed opposite one another and are adapted to support the sides of the drill bit and constrain material squeezed out of a blank by the forging wheels, the axes of said rollers lying in first and second substantially parallel roller axis planes; and wherein:

i) said roller and wheel axis planes are substantially mutually perpendicular and are each parallel said blank axis and the direction of draw of said blank between the wheels and rollers.

5. A drill bit having two opposed helical flutes and a web between said flutes which tapers by at least 50% from a shank end of said flutes to a working end of the drill bit, wherein the drill bit is roll formed from a blank, characterised in that the cross-section of the drill bit changes from its shank end to its

working tip, such cross-section comprising quadrants defined by a diameter of the section from a front cutting lip of one flute to the corresponding cutting lip of the other, each flute primarily occupying opposing flute quadrants, wherein such cross-section changes from shank end to working tip not only by virtue of a decreasing web thickness, but also by the flute increasingly being incursive into the quadrant ahead of the flute quadrant in the direction of cutting rotation of the drill bit.

6. A drill bit as claimed in claim 5, wherein said incursion is substantially parabolic in shape.

The Patent Office

21

Application No:	GB 9604544.8	**Examiner:**	Vaughan Phillips
Claims searched:	1-6	**Date of search:**	16 April 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): B3C; B3M (ME, MG)

Int Cl (Ed.6): B21H, B23B

Other: Online: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
	NONE	1, 3, 5

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
A Document indicating technological background and/or state of the art.
P Document published on or after the declared priority date but before the filing date of this invention.
E Patent document published on or after, but with priority date earlier than, the filing date of this application.